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Cover: Signal cables are laid out at nuclear weapons test facility at Yucca Flat, Nev., before being lowered into test hole (beneath tower) with weapons canister. Photo courtesy of Department of Energy

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LETTERS

Waste in space

SIR: I am writing to draw the attention of C&EN readers to a statement by Jacques Cousteau in his December 1987 *Calypto* log, in which he expresses his apprehension of the Strategic Defense Initiative program.

Cousteau points out that the antisatellite testing that the U.S. has already started is littering space with thousands of small fragments traveling at a speed of Mach 20—10 times the speed of the Concorde.

He describes "this latest fad in military technology...destroying military satellites and intercontinental missiles with laser beams" as "yet another distressing example of our criminal inability to manage the progress of technology."

His dire conclusion: "If we do not take action, this waste will become an almost impenetrable shield which could prevent, perhaps for a thousand years, our access to space. Ironically, it is the conquest of space itself, handled in a way that defies common sense, that could nail us definitively to Earth."

Alan Rhodes
Willoughby, Ohio

Alcohol in gasoline

SIR: I just became aware of Donald F. Othmer's letter on methanol to gasoline (C&EN, Nov. 30, 1987, page 2), and feel that I should offer some rebuttal.

It is true that I spent 32 years with what is now Exxon at Baytown, Tex., but I retired involuntarily in 1971 as a result of a large reduction in research funding. I spent the next 10 years at the University of North Dakota, first as project manager of Project Lignite, and then as principal investigator and adjunct professor of chemical engineering.

With regard to Othmer's reference to E. E. David, it is certainly true that methanol is "the lowest-cost liquid available from coal" if indirect liquefaction is the only process considered for coal conversion. Of course Exxon Research has done extensive and apparently successful work on the direct liquefaction of coal to produce liquid hydrocarbon fuels. This work came to an end as a result of the lowering of OPEC crude oil prices.

The problems caused by alcohol in motor fuels are well recognized in the Midwest, where a number of service stations advertise: "Our gasoline contains no alcohol." The stations selling motor fuels that contain alcohol either do not advertise it or mention it in small print as required by law. The reason for alco-

hol in the motor fuels is the subsidies supplied by the U.S. and by some farm states for the use of agricultural alcohol.

I know that methanol is the fuel of choice for high-performance engines, where fuel economy and engine life are not the primary considerations as long as the vehicles can finish the race. As I mentioned before, I have and would use such a fuel in these circumstances. However, I was somewhat surprised by the claim of greater safety, since methanol has much wider flammability limits than the hydrocarbons used in motor fuels. Further, it burns with a very clean nonluminous flame, which has resulted in burns to pit crewmen who inadvertently approached too close to flames in a fire during a pit stop. This was dramatically illustrated some years ago during a televised Indianapolis 500.

I do not have access to the article referred to by Othmer on the fuel test, but it is not surprising that the alcohol blend gave equivalent or slightly greater fuel economy than the straight gasoline if no changes were made in the engine. Conventionally carbureted gasoline engines are usually set to run slightly rich to ensure that an adequate mixture reaches the more distant cylinders. The result of adding the methanol, in addition to increasing octane number and reducing the tendency to knock, would be to lean the mixture at the same fuel-to-air ratio and improve efficiency somewhat. The same sort of result might be obtained by water injection, and indeed devices for that are advertised in some publications. Efficiency could also be improved with the gasoline fuel by increasing the octane number and leaning the mixture.

The folks advocating the use of alcohol are attempting to accomplish this by political means, as in the attempt in the California legislature. This reminds me of the old saying: "Technology tells us what can be done. Economics tells us what should be done. Politics tells us what will be done."

A. M. Souby
San Marcos, Tex.

Correction

• Feb. 1, page 39: In the listing of Toronto hotels and their rates for the 3rd Chemical Congress of North America/195th ACS national meeting, the exchange rate between the U.S. and the Canadian dollar was inverted. The correct rate is \$1.00 U.S. equals about \$1.27 Canadian.

Nuclear Weapons Testing

Issue of further testing constraints
reignites in wake of
shifting U.S. and Soviet attitudes

NEWS ANALYSIS

Michael Heylin, C&EN Washington

Ever since the first nuclear test explosion 43 years ago, there have been efforts to ban, or at least constrain, such tests. Such efforts have been spotty and have met with only modest success.

For 25 years there have been treaty limits on where tests can be conducted: They must be underground. For 12 years there have been limits on their size: not larger than the equivalent of 150 kilotons of TNT. But these constraints have done nothing to hamper development and deployment of new nuclear weapons systems. There are no treaty limits on the number of tests and they go on unabated. Last year there were 47 worldwide. The long-term average is 42 per year.

That first nuclear blast, which brightened the early morning sky near Alamogordo, N.M., on July 16, 1945, has been followed by more than 1750 nuclear explosions conducted by at least six nations.

Nuclear testing has long had the characteristics of a major, established business. The Nevada Test Site, the location of all current U.S. tests, has been in operation since 1951. It covers an area bigger than Rhode Island. With 8500 employees, it has the largest payroll in Nevada. Its annual budget is approaching \$1 billion.

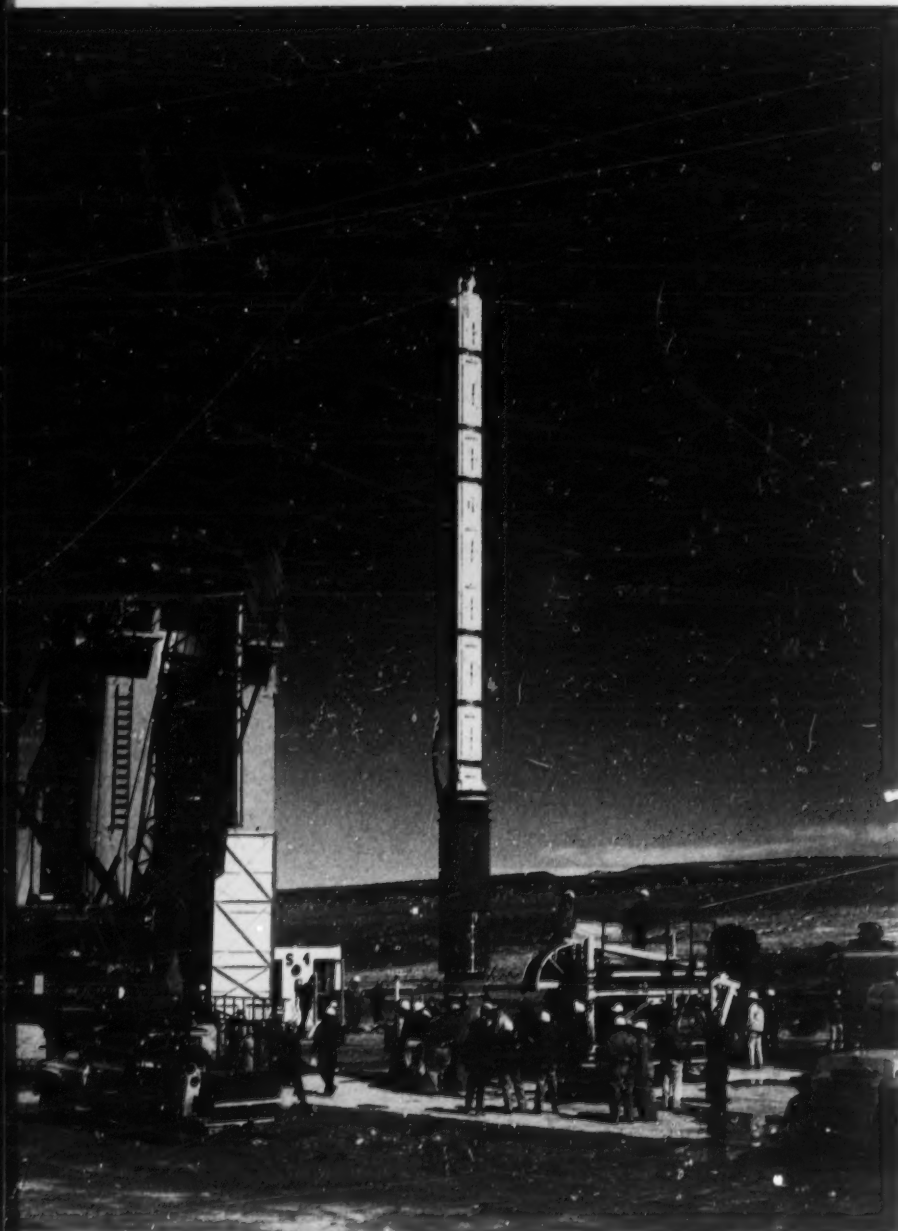
The Soviet Union's primary test site, in Kazakstan, near Semipalatinsk, is of similar dimensions. The

French have a major testing facility at Mururoa in the South Pacific. The Chinese have a testing operation in Xinjiang. The British test their weapons at the Nevada Test Site under a cooperative agreement with the U.S. The only other nation known to have conducted a test is India, with just one, in 1974.

Despite this seeming inevitability of continued nuclear weapons testing, the issue of a ban that would either stop it altogether or put it under much tighter control has been a focus of intense and growing contention in this country and abroad.

Both sides in this debate agree on one thing—that a comprehensive ban on all testing or a ban on all tests above a low threshold, such as 1 kiloton, would prevent the development of new nuclear weapons systems, including so-called third-generation, directed-energy weapons. For those who favor continued reliance on technology in defense matters, this is anathema. For those who seek constraints, it is the very purpose of an agreement.

The issue has been marked by shifts in attitude by the superpowers in recent times. The Reagan Administration sees a comprehensive test ban only as a very long-term goal for the U.S. It says that even more modest limits on testing can come only in step with a long process of nuclear arms reductions and that a comprehensive ban would be appropriate only when nuclear deterrence no longer underpins national security. Another new factor has been the need for nuclear testing in support of the Strategic Defense Initiative launched by President Reagan in March 1983 and now the cornerstone of U.S. defense policy.



Department of Energy photos

A nuclear device and diagnostic canister are lowered down an emplacement hole prior to testing at Pahute Mesa in the northwest corner of the Nevada Test Site, the location for higher-yield tests

measure nuclear explosions at Nevada and Semipalatinsk.

The Department of Energy, the agency responsible for developing and producing nuclear weapons, sees a comprehensive test ban as ill advised at this time. The department argues that as long as the U.S. relies on nuclear weapons for deterrence, it must have the right to test them to assure the reliability of the stockpile, to keep current weapons systems up to date and safe, to develop new ones, and to test the effects of radiation on military equipment.

Proponents of a testing ban argue that the continuous modernization of nuclear arsenals brings not enhanced security, but greater danger and instability. They also insist that the reliability of weapons in today's stockpile can be assured adequately without continued nuclear testing.

Another argument concerns the monitoring of testing limits. The Administration contends that the Soviets have likely violated the 150-kiloton limit, and that even this 150-kiloton level cannot be monitored with confidence. Proponents contend there is no unambiguous evidence of Soviet violation of the 150-kiloton provision. And they argue that modern seismic methods, backed up by other intelligence-gathering assets, are adequate for monitoring testing threshold far below the current 150 kilotons.

The role of Glenn T. Seaborg

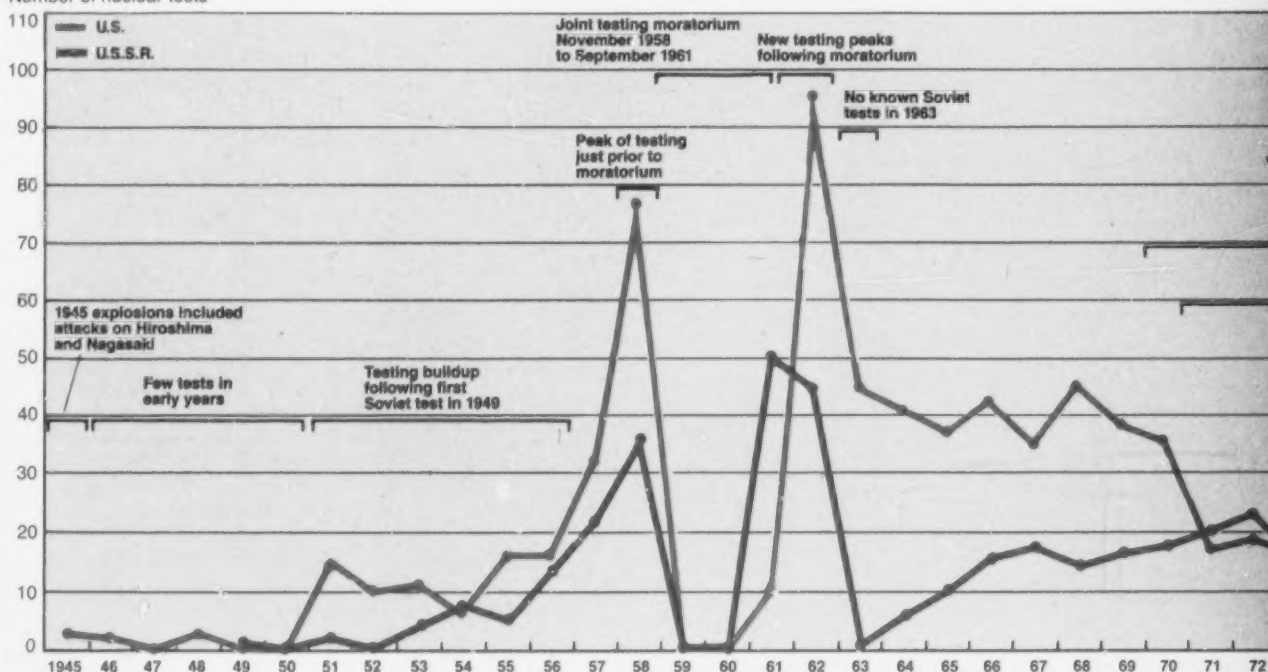
A chemist who has been at the center of all these issues for almost three decades is Nobel Laureate Glenn T. Seaborg. He headed the Atomic Energy Commission, the agency then responsible for nuclear weapons, from 1961 to 1971.

The Soviets, on the other hand, have been pushing extremely hard lately for a ban on all testing. They have become more accommodating concerning adequate mechanisms, such as on-site inspections, for monitoring such a ban. They have allowed U.S. scientists to install and operate seismic monitoring equipment on their territory. And they unilaterally halted their own testing from August 1985 to February 1987 and state they would stop testing again "tomorrow" if the U.S. also would stop.

But after a hiatus of eight years the superpowers are at least talking to one another again at the diplomatic level about nuclear testing. What are formally known as Nuclear Testing Talks were opened last fall in Geneva. The first order of business is working out details of a joint verification experiment in which teams of experts from each side will work together to

U.S. and Soviet Union have conducted between them about 1500 nuclear tests over past 43 years

Number of nuclear tests^a



^a Annual totals include defense-related tests and so-called peaceful nuclear explosions (PNEs). Sources: Natural Resources Defense Council, Department of Energy

As head of AEC, Seaborg was involved in the negotiations with the Soviet Union and the U.K. that led to the signing of the Limited Test Ban Treaty (LTBT) in Moscow on Aug. 5, 1963. This agreement bans tests in the atmosphere, in space, and underwater. Only an impasse over the number of obligatory on-site inspections prevented this treaty from being comprehensive by also banning underground testing. Seaborg thinks that the U.S. was wrong in 1963 in its insistence on the on-site inspections issue. His view is that the world would be far better off if the treaty had banned all testing. He remains an active advocate of a comprehensive test ban (CTB) and was keynote speaker at a conference on nuclear testing issues just last month in Las Vegas.

A former president of the American Chemical Society, Seaborg articulated his views in a letter published in the June 13, 1983, issue of C&EN. He stated that, "A CTB would halt that aspect of the arms race that is most threatening, the qualitative improvement in nuclear weapons. Such improvements in offensive weapons continue to make them ever more dangerous. Improvements in defensive weapons might tempt either side to launch a first strike on the assumption this can be done with relative impunity or needs to be done before the other side achieves an effective defense."

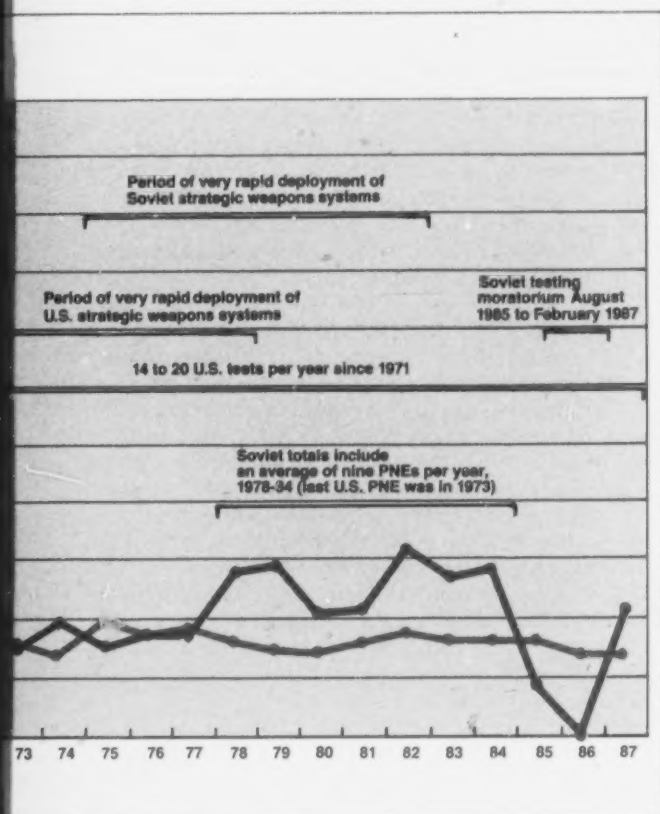
Seaborg's letter triggered considerable interest among ACS members and, incidentally, became something of

a hot potato for the staunchly apolitical society. The ACS Board of Directors defeated a motion that it support a CTB by a vote of 10 to four. But a number of local sections called for at least a discussion of the issue. After the matter had been bounced around the society for some time, Ellis K. Fields, ACS president in 1985, made nuclear testing the subject for his presidential plenary session at the society's national meeting in Chicago in the fall of that year.

In his address in Las Vegas, Seaborg said he is certain that President John F. Kennedy and Nikita Khrushchev would have followed up on the treaty's charge to its signatories to continue negotiations to "achieve the discontinuance of all test explosions of nuclear weapons for all time." But within just over a year of the signing of the treaty Kennedy was dead and Khrushchev out of power.

The history of testing

Like Kennedy, President Dwight D. Eisenhower worked actively for nuclear testing constraints. And he might have reached an agreement if U.S.-Soviet relations had not soured in 1960. But he was instrumental in the nuclear test moratorium that started in November 1958. This total pause in U.S. and Soviet testing ended after almost three years on Sept. 1, 1961, when the Soviets, without prior announcement, started a major program of tests in the atmosphere. By year's end, they had conducted about 50 tests. The U.S.



resumed testing 14 days after the Soviets. By the end of 1961, it had conducted 10 low-yield underground tests at the Nevada Test Site. On April 24, 1962, the U.S. started a program of atmospheric tests at Christmas Island and other Pacific locations that went on all year. The U.S. conducted a record total of 96 tests in 1962. Since 1971, U.S. and Soviet weapons testing programs each have settled down to an average of between 15 and 20 such tests per year.

Since 1976, U.S. weapons tests and, according to most experts, probably all Soviet tests have been within the 150-kiloton framework spelled out in a bilateral agreement, the Threshold Test Ban Treaty (TTBT), signed by President Richard M. Nixon and Leonid Brezhnev in Moscow on July 3, 1974. A similar 150-kiloton limit was placed on so-called peaceful nuclear explosions as a result of another treaty, the Peaceful Nuclear Explosion Treaty (PNET), signed in Moscow by Brezhnev and President Gerald R. Ford in 1976.

Unlike his predecessors, President Jimmy Carter never got to sign a nuclear testing agreement. On coming to office, Carter made no effort to push for Senate ratification of the TTBT and the PNET. Instead, Carter pushed for a comprehensive treaty in negotiations that opened in the fall of 1977. Agreement in principle was reached on such previously touchy issues as in-country seismic monitoring stations and on-site inspections. But many important details remained unresolved and in the end Carter decided that

the inevitable controversy that would erupt in the Senate over ratification of a test ban treaty would likely endanger the SALT II agreement, the centerpiece of his arms control program.

The case for testing

One of the most articulate spokesmen for continued testing is George H. Miller, associate director for defense systems at Lawrence Livermore National Laboratory, the organization, which, along with Los Alamos National Laboratory, is responsible for developing nuclear weapons.

In an address at last year's annual meeting of the American Association for the Advancement of Science entitled "Avoiding Nuclear Escapism," he stated that, "For the foreseeable future the stability of the strategic balance and the security of the nation will depend on nuclear weapons. Our ability to maintain the stability of the present deterrent depends in an intimate way on our ability to continue to test nuclear weapons." He went on, "We should not delude ourselves into thinking that a nuclear test ban would enhance the safety of our country. It may, in fact, do quite the opposite. A comprehensive test ban may be the correct last step in our quest for nuclear arms control and a stable peace. But it would be a disastrous first step for the U.S. to take."

He also pointed out that nuclear testing has enabled the U.S. to reduce its stockpile of strategic and tactical nuclear warheads some 25% from its peak in the late 1960s and to cut its total destructive force about 75%.

What Miller did not point out, however, was that the number of U.S. strategic warheads has grown from about 4000 in 1970 to about 11,000 today, while the Soviet strategic arsenal has increased from about 2000 warheads to about 10,000. Continued testing also has allowed deployment by both sides of missiles with accurate multiple warheads—the very weapons



Seaborg: stop qualitative improvements



This crater, the largest on the Nevada Test Site, was formed in July 1962 in a test of the effectiveness of nuclear explosions for massive earth excavation. The test involved a 100-kiloton device, buried 635 feet deep

that have caused the perceived "window of vulnerability" of such concern to the current Administration and the spur for the modernization of the U.S. arsenal in recent years.

The verification issue

The contention that nuclear testing is still needed for the development of new weapons systems is not amenable to technical dispute and analysis. It is a matter of defense policy, a purely political issue. But the claims that nuclear testing constraints cannot be adequately monitored and that the reliability of the current stockpile is dependent on continued testing have generated heated technical discussion.

The Administration's claim that the Soviets have likely violated the 150-kiloton provision of the 1974 treaty has been particularly hotly disputed, and not only by those outside the defense establishment.

The U.S. monitors this treaty through a worldwide network of seismic instruments known as the Atomic Energy Detection System. This teleseismic method involves measurement of the vibrations triggered in the Earth and along its surface by nuclear explosions.

The U.S. has not been able to calibrate the Semipalatinsk test site against test explosions of known size. Extensive data calibrating the Nevada Test Site have not been particularly useful because of the dif-

ference in geology between Nevada and Semipalatinsk. Geologically the Soviet site is older and harder than Nevada. When Soviet tests are measured seismically they appear larger than Nevada tests of the same size unless an appropriate "fudge" factor is used. The argument has been over how large this factor should be.

The Administration continues to rely on a factor that indicates the Soviets have exceeded the 150-kiloton limit more times than the treaty allows under a so-called "whoops" clause, which allows for the uncertainty of yield measurements.

Miller told the AAAS meeting that Lawrence Livermore believes that the Soviets have complied with the treaty, although it cannot be sure there haven't been a few tests above 150 kilotons. In 1986 the Central Intelligence Agency revised its estimate of the size of Soviet tests downward by 20%. And government witnesses before a hearing of the House Permanent Select Committee on Intelligence last September did not support the charge of Soviet violations.

The committee's report, dated Nov. 19, states that, "National nuclear laboratory scientists noted that U.S. and Soviet tests exhibit a remarkably similar distribution in the number of tests now appearing to be above 150 kilotons. The executive branch characterization of Soviet behavior as a 'likely' violation is questionable and deserves re-evaluation."

However, the Administration has hung tough on this issue of monitoring. It insists the teleseismic method is just not good enough for adequate verification. It says that this method has an uncertainty factor of 2.0 at the 95% confidence level. This means that there is a one-in-40 chance that a test measured at 150 kilotons was actually more than 300 kilotons. Soviet scientists claim that the uncertainty factor is well below 2.0 and adequate for verification.

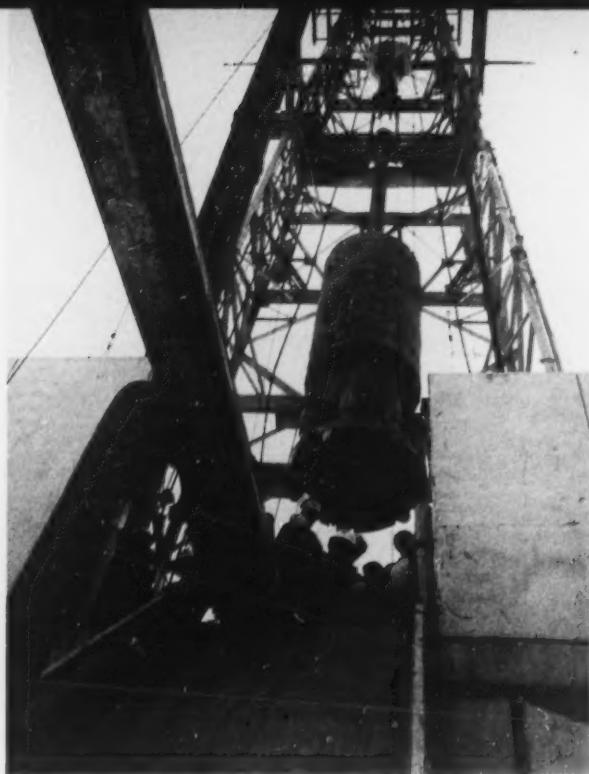
For some time the Administration has been propos-

Most U.S. tests are for weapons development



Total tests = 899*

* Through 1987 Source: Natural Resources Defense Council



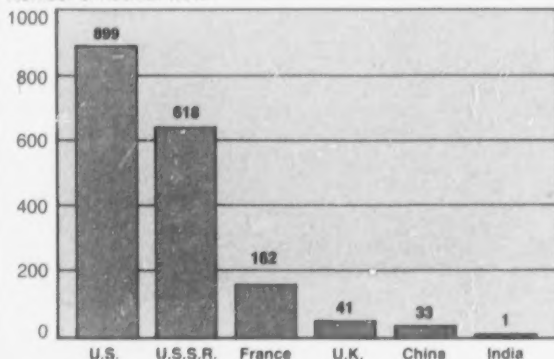
Underground nuclear tests are conducted in emplacement holes up to 12 feet in diameter and 5000 feet deep drilled by special large-diameter bits. Bits and steel collar above may weigh more than 200 tons

ing a hydrodynamic method for monitoring the TTBT. It invited the Soviet Union to send experts to the Nevada Test Site to observe a demonstration of this technique. At first the Soviets refused, wanting to leapfrog the issue of TTBT verification and move directly to negotiations on a comprehensive test ban that involves monitoring at much lower levels.

The Administration has prevailed. Last September Secretary of State George P. Shultz and Soviet Foreign Minister Eduard Shevardnadze announced agreement on stage-by-stage negotiations on nuclear testing. The

U.S. has conducted half of all nuclear tests since 1945, the Soviets one third

Number of nuclear tests*



* Through 1987 Source: Natural Resources Defense Council

first step is to agree on verification methods for the TTBT and the PNET. The next step will be negotiations on intermediate testing limitations. The third will be consideration of a comprehensive ban.

The hydrodynamic method being proposed is known as CORRTEx, an acronym for Continuous Relectometry for Radius versus Time Experiment. It involves the placement of a cable, attached to an electrical unit and a microcomputer on the surface, in a satellite hole about 45 feet from the emplacement hole holding the nuclear device. When the device is exploded the cable is crushed and short-circuited by the shock wave. The speed with which this crushing moves up the cable is measured by the electrical unit and the results translated into an estimate of yield.

The Administration claims that CORRTEx has an uncertainty factor of 1.3 or less. But the method has some drawbacks. First, there are not a lot of data on it. It has been used at the Nevada Test Site more than 100 times with the cable down the emplacement hole, but only four times using a satellite hole. Second, the Soviets claim its uncertainty factor would be higher than 1.3, and not significantly better than the teleseismic method, when conducted by a second party without total knowledge of the device being tested. Third, it would be very intrusive as those conducting the test would have to be on site. And, fourth, adopting it would involve a major revision of the TTBT.

In addition, the intelligence committee report states that, "Given the current U.S. capacity to monitor a 150-kiloton threshold, and emerging research on improving U.S. yield estimation techniques, continued executive branch insistence on additional specific verification methods for the TTBT and PNET before they are ratified is debatable."

Despite these problems and criticisms, plans are going ahead to use CORRTEx in the joint tests at Nevada and Semipalatinsk later this year. Teams of 20 Soviet and U.S. experts made familiarization trips to the two sites last month. This week they reconvene in Geneva to start working out details for the tests.

An Arms Control and Disarmament Agency official on the U.S. team tells C&EN that the aim of the tests is for each side to convince the other of the feasibility and adequacy of its "preferred" verification method: CORRTEx for U.S. and seismic for the Soviets. He stresses that the effort so far has been very cooperative and both sides are anxious to have the TTBT and PNET quickly ratified. The test blasts will be a little below the 150-kiloton level. The first could be as early as May, possibly the one at Semipalatinsk, with the Nevada test following later in the year.

Joint testing

The joint experiment planned for this year represents an unprecedented degree of cooperation by the U.S. and Soviet defense establishments. However, to its critics, it represents a lengthy digression from what they perceive as the more important issue of working toward either a comprehensive or a much reduced threshold treaty. The Soviets have been cooperative in this endeavor, too. But in this case with a private



Yucca Flat within the Nevada Test Site is the location of most current underground nuclear weapon tests. It is dotted with more than 200 craters formed by subsidence following such tests

organization, and somewhat at the displeasure of the Administration.

Since 1986 the Soviet Academy of Sciences and the Natural Resources Defense Council, a Washington, D.C.-based group, have been conducting a joint seismic project with the aim of demonstrating that verification is not an obstacle to a nuclear test ban or moratorium.

NRDC scientists have been manning seismic stations near the Semipalatinsk site since September 1986. This year the network of three stations will be increased to five and relocated about 600 miles from the site in order to focus on research on what would be needed to verify a 1-kiloton test limit nationwide. The stations have not been allowed to measure actual Soviet tests since the Soviets renewed testing a year ago. The Soviets insist they are turned off during tests. But the stations have been used to measure three chemical explosions of known size and they will be allowed to measure Soviet nuclear tests once they are relocated. Similar seismic stations have been established near the Nevada Test Site. And test chemical explosions are planned for later this year.

U.S. officials have tended to play down the significance of the NRDC project. They stress that it is not helpful to have a private group involved directly with the Soviets in such matters. NRDC personnel, on the other hand, feel that their effort may have helped to get the U.S. government off dead center.

Monitoring a comprehensive or low-threshold test ban is a far more formidable task than monitoring a 150-kiloton limit. The intelligence committee report states, "Monitoring a CTB would present a major technological and management challenge to the U.S. intelligence community. The deployment of a compre-

hensive monitoring capability for a CTB would require several years and hundreds of millions of dollars not currently programed by U.S. intelligence."

One of the few consensuses on this complex issue is that, technically, a monitoring system can be as good as negotiators would want to make it with in-country seismic stations, in-country radiation monitors, satellite surveillance, mandatory on-site inspection, data exchanges, and other cooperative measures. But no system could ever guarantee zero nuclear explosions. The key issue is how good it would have to be to give acceptably high confidence that the other side could not conduct a clandestine testing program of military significance.

There is little disagreement that any nuclear explosion above 15 kilotons can readily be detected and distinguished from earthquakes with current teleseismic means. Advocates of a testing ban, such as seismologists Lynn R. Sykes of Columbia University and Jack F. Everden of the U.S. Geological Survey, have long argued that a 1-kiloton detection level could readily be reached.

But two issues are constantly raised concerning the reliability of a test ban. One is the problem of differentiating small clandestine tests from literally thousands of small earth tremors and industrial chemical explosions. Test ban advocates respond that the large majority of small earthquakes could readily be identified as such because they occur under the oceans or at depths too great to be nuclear tests. Most industrial explosions could be confirmed from their location. The remaining uncertain incidents could be checked by satellite or other means or, as a last resort, by on-site inspection.

The other major issue is that of decoupled nuclear

explosions. These are explosions set off in large underground caverns. This would reduce the vibrations they would cause and reduce their apparent size, when measured seismically, by a factor of 10 or more.

However, according to Jeremy K. Leggett of the Royal School of Mines in London, decoupled explosions have their drawbacks for potential evaders of a test ban agreement. He discussed what he calls the "evasion gauntlet" that a clandestine testing program would have to run at the Las Vegas meeting last month.

He pointed out that nuclear explosions of much less than 1 kiloton have been distinguished teleseismically more than 4000 km from their source. Under a treaty, a clandestine testing program would have to deceive in-country monitors at much shorter distances.

Leggett, who has studied the monitoring issue for many years, also points out that very little is actually known about decoupled nuclear explosions. The U.S. has conducted only one such test. There is also the problem of the availability of suitable caverns. They have to be the right size and shape and the right depth. Also they must not allow the release of readily detectable radioactive debris to the atmosphere. If man-made, such caverns would involve major, and hence potentially detectable, engineering projects. Also such caverns are most easily constructed, and more likely to occur naturally, in areas of salt strata. Such areas in the Soviet Union are reasonably well-known and would likely be closely monitored by in-country seismic stations. Also such areas are relatively quiet seismically. Hence any nuclear test would be more likely to cause suspicion.

The reliability issue

The argument over the need for continued nuclear testing to assure confidence in the reliability of warheads in the current U.S. stockpile hinges largely on classified data. The public is left to decide which of the very conflicting views expressed by weaponeers with current or recent access to the secret data to believe.

Lord Solly Zuckerman, a former long-time chief science adviser to the British government, expressed this dilemma best a few years ago when he wrote that the men in the nuclear weapons laboratories of both sides "have become the alchemists of our time, working in secret ways which cannot be divulged, casting spells that embrace us all."

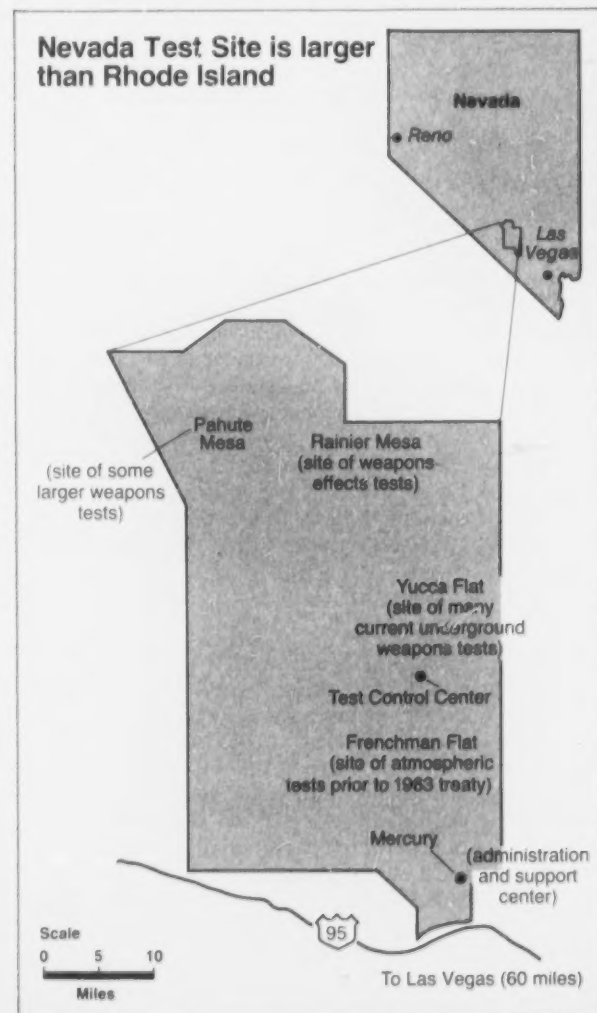
However, both Congress and the science community have found ways to raise the central question of why the weapons labs insist that testing for weapons reliability is still essential, 25 years after the U.S. formally committed itself to negotiate an end to all weapons testing for all time.

In March last year Rep. Les Aspin (D-Wis.), chairman of the House Armed Services Committee, and five other members of Congress asked Roger Batzel, director of Lawrence Livermore, to allow Ray E. Kidder, a veteran physicist at the lab, to prepare an independent review of the need for so-called proof testing of the current stockpile. Kidder had earlier published a critique of a study by a DOE contractor on the issue.

Batzel agreed. He also had associate director Miller prepare a parallel report. Both reports were released in October.

Kidder's major conclusion was that, "A high degree of confidence in the reliability of the existing stockpile is justified, and that it is sufficiently robust to permit confidence in the reliability of remanufactured warheads in the absence of nuclear explosive proof-tests." He also contested the laboratory's claim that continued testing is needed because 14 of 41 warheads placed in the stockpile since 1958 needed such testing to assure their reliable operation.

According to Kidder, the experience with these 14 weapons "has little if any relevance to the question of maintaining the reliability of nuclear weapons that exist in 1987." He says nine of the 14 were weapons deployed just before or during the 1958-61 moratorium and, hence, were inadequately tested prior to deployment. He also claims that the postdeployment tests of the remaining five systems would not have been needed if they had been subjected to the more rigorous standards of nuclear testing now routine.



A history of nuclear testing and efforts to control it

- 1945—First nuclear test at Alamogordo, N.M.
—Attacks on Hiroshima and Nagasaki.
- 1947—Unsuccessful efforts to place nuclear matters under international control.
- 1949—First Soviet nuclear test.
- 1952—First British nuclear test.
- 1954—Increasing worldwide concern over health effects of nuclear testing in the atmosphere.
- 1958—Start of U.S.-Soviet moratorium on nuclear testing.
- 1960—First French nuclear test.
- 1961—Renewal of testing by Soviet Union, then by the U.S.
- 1962—Record 96 tests by the U.S.
- 1963—Limited Test Ban Treaty (LTBT) signed by U.S., Soviet Union, and U.K. and ratified by U.S. Senate (banned all but underground testing).
- 1964—First Chinese nuclear test.
- 1968—Nuclear Nonproliferation Treaty signed, committing nuclear powers to negotiating in good faith to end nuclear arms race at an early date.
- 1969—Nuclear Nonproliferation Treaty ratified by Senate.
- 1974—Threshold Test Ban Treaty (TTBT) limiting tests to 150 kilotons signed by U.S. and Soviet Union. (Both sides claim to have abided by this treaty, which has not yet been ratified by the Senate.)
—First and only Indian nuclear test.
- 1976—Peaceful Nuclear Explosions Treaty signed (not yet ratified by Senate).
—TTBT went into effect.
- 1979—U.S.-Soviet negotiators make progress toward a comprehensive test ban treaty (CTBT).
- 1980—CTBT talks suspended following Soviet military action in Afghanistan.
- 1982—U.S. formally breaks off talks on CTBT.
- 1985—Start of unilateral Soviet moratorium on testing.
—U.S. seeks Soviet cooperation in exploration of ways to verify compliance with 150-kiloton limit of TTBT.
- 1987—Soviet Union renews testing.
—U.S.-Soviet talks on testing issues reopened.
- 1988—Exchange of visits by U.S. and Soviet weapons experts to testing sites to plan joint verification experiment.

Miller's report is a broader review of the various reasons for continued testing, especially the need to maintain an expert and experienced work force in the nuclear weapons community. He also states that the reliability of current weapons is very high and that most problems can be handled with nonnuclear testing. But he points out that nuclear weapons are subject to aging and that no weapons can be tested enough prior to deployment to guarantee no further nuclear testing will be needed.

The scientific community questioned the need for continued testing through more than 200 letters to David P. Gardner, president of the University of California, which manages the weapons labs for DOE. The

letters were from University of California faculty members. They asked if today's nuclear weapons do, indeed, require continued testing and if the laboratory's weapons design policies were impeding the stated national goal of a comprehensive test ban.

The issue was referred for study to the Scientific & Academic Advisory Committee (SAAC), which provides Gardner with technical oversight of the labs. The subsequent report by SAAC does not directly address the issue of whether continued testing is needed to assure reliability in today's arsenal. But it states that the labs have "designed weapons that have been remarkably reliable and long-lived."

The report points out that weapons are prepared in accordance with so-called military characteristics provided by the Department of Defense in order of priority. In 1977 a "desirable" characteristic was introduced to address stockpile reliability and remanufacture. But it has not been assigned a priority. SAAC concludes that weapons have not been deliberately designed to require continued testing. On the contrary, according to SAAC, "In the past decade, increased emphasis on warhead endurance appears to be resulting in weapons that have even fewer problems in the stockpile."

The outlook for a ban

During the past two years the House has twice voted in favor of limiting nuclear testing to 1 kiloton or less if the Soviets do the same. The Senate has not gone along, being content with a nonbinding resolution encouraging the reopening of talks with the Soviets. But the pressure for progress on nuclear testing remains strong, if somewhat diluted, with the signing of the treaty on intermediate-range nuclear forces and the prospects of an agreement on reducing strategic forces later this year.

A lot will be decided concerning the future of test ban negotiations in November with the Presidential elections. If one of the Republican aspirants is successful, there likely will be little change from the current posture.

But if any of the Democratic aspirants becomes President there will be a strong call for change. All seven Democrats still in the race favor a test ban. Most give it high priority. Most state that they would call for a mutual testing moratorium with the Soviets as an early step. Of course, the opposition from the defense and weapons establishment will remain strong.

On the international scene there is growing, if still not compelling, pressure for the U.S. and the Soviet Union to finally live up to their 25-year-old commitment to negotiate a comprehensive ban. For instance, late last year the general assembly of the United Nations voted 128 for, three against, with 22 abstentions in favor of a proposal that the nonnuclear-weapons states submit an amendment proposal to change the LTBT into a comprehensive testing ban. The no votes were from the U.S., the U.K., and France.

This proposal very likely won't go anywhere. But the issue of nuclear weapons testing is not going to go away either, domestically or internationally. □